NON-PUBLIC?: N
ACCESSION #: 9110110142
LICENSEE EVENT REPORT (LER)

FACILITY NAME: JAMES A. FITZPATRICK NUCLEAR POWER PAGE: 1 OF 9
PLANT

DOCKET NUMBER: 05000333

TITLE: Manual reactor shutdown due to inoperability of both Low Pressure Coolant Injection subsystems due to mechanical failure of on valve in each of the two systems

EVENT DATE: 05/07/91 LER #: 91-006-01 REPORT DATE: 10/04/91

OTHER FACILITIES INVOLVED: DOCKET NO: 05000

OPERATING MODE: N POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION:
50.73(a)(2)(i)

LICENSEE CONTACT FOR THIS LER:
NAME: Hamilton C. Fish TELEPHONE: (315) 349-6013

COMPONENT FAILURE DESCRIPTION:
CAUSE: X SYSTEM: BO COMPONENT: 84 MANUFACTURER: L200
X BO ISV P305

REPORTABLE NPRDS: Y
Y

SUPPLEMENTAL REPORT EXPECTED: No

ABSTRACT:

EIIS Codes are in ! - UPDATE REPORT - ORIGINAL REPORT DATE 6/6/91

Between 0400 and 0500 on 5/7/91 a monthly Technical Specification check found one of the two primary containment isolation valves in both residual heat removal BO! low pressure coolant injection (LPCI) BO) subsystems to be inoperable. One valve operator torque switch tripped in both directions preventing both full closure and full opening. The other valve had excessive seat leakage. The inoperability of both RHR/LPCI systems required a reactor shutdown within 24 hours which was initiated

and an Unusual Event declared at 1237. The reactor was manually scrammed at 1820 achieving cold shutdown on 5/8/91 at 0330. The Unusual Event was terminated at 0400. In LPCI loop B the threads of the gate valve stem nut in the motor operator were worn and broken causing the valve to lock in a partially open position. The stem nut was replaced and LPCI loop B restored to service at 1410 on 5/12/91. The stem of an angle globe throttle valve in loop A was broken inside the valve body. The disc, disc guides, and seat were severely damaged. The valve was removed from the system and repaired. Analysis determined stem nut wear out may have been accelerated by mechanical overload caused by high differential pressure across the valve. The valve stem failed due to throttle flow induced vibration causing cyclic fatigue.

END OF ABSTRACT

UPDATE REPORT - ORIGINAL REPORT DATE 6/6/91

EIIS Codes are in !

Description

The reactor was operating at full power. In accordance with Technical Specifications, a scheduled monthly surveillance test was performed on 5/7/91. Two motor operated primary containment isolation valves failed to meet the operability test acceptance criteria. Each of these valves is located in a separate and redundant low pressure coolant injection (LPCI) BO! subsystem of the residual heat removal (RHR) BO! system which provides emergency core cooling (ECCS). The RHR system is divided into redundant loops. Each of the loops contained one of the two valves that were not operable. Therefore, both RHR/LPCI loops were inoperable. The reactor was shutdown within 24 hours in accordance with Technical Specification Requirement 3.5.A.6.

In each of the two RHR system loops, two pumps discharge through a 24-inch diameter common header to the discharge piping of the reactor water recirculation system AD! piping. The isolation protection for the penetration of the primary containment for each loop is provided by three valves. An air operated testable check valve is used inside containment. This check valve is permitted to have a higher leak rate than other containment isolation valves. Therefore, primary containment isolation capability outside of the drywell is provided by two motor operated valves. Closest (inboard) to containment is a gate valve, 10MOV-25A/B. Next outboard is an angle globe valve, 10MOV-27A/B, which may also be used for throttling RHR flow.

Technical Specification surveillance requirement Section 4.5.A.3 requires testing of the RHR/LPCI subsystem as specified in section 4.5.A.1.d which requires a monthly operability test of motor operated valves (MOVs). The test on May 7, 1991 was conducted in accordance with Operations Department surveillance test procedure ST-2B, "RHR Pump and MOV Operability and Keep Full Level Switch Functional Test". To open the normally closed inboard valve 10MOV-25A/B, the differential pressure across the gate disc is first equalized by pressurizing the space between 10MOV-25A/B and outboard valve 10MOV-27A/B. During the performance of ST-2B at 4:05 A.M. on May 7, 1991, operators were unable to equalize pressure across the closed 10MOV-25A valve. RHR header pressure upstream of 10MOV-27A increased when the space between 10MOV-27A and 10MOV-25A was pressurized. These observations indicated that outboard angle globe valve 10MOV-27A was leaking at an undetermined rate. The valve (10MOV-27A) was therefore not able to perform the primary containment isolation function and was

declared to be inoperable. This placed the plant in a seven-day Limiting Condition for Operation (LCO) as specified in Technical Specification Section 3.5.A.3.a. Performance of ST-2B on the RHR/LPCI loop A was necessarily suspended.

At 4:45 A.M., while performing ST-2B on the RHR/LPCI loop B, the normally closed LPCI inboard injection gate valve 10MOV-25B failed to open fully and then failed to fully close. The motor operator torque switch tripped the power supply to the operator motor prior to completion of attempts to both open and close the valve. Operators were also unable to operate the valve using the manual handwheel because the motor operator could not be manually declutched.

Both loops A and B of the LPCI mode of the RHR/LPCI system were now in an inoperable condition due to one inoperable valve in each loop. Technical Specification 3.5.A.6 requires that the reactor be placed in a cold condition within 24 hours whenever both LPCI subsystems are inoperable.

At 12:37 P.M. a reactor shutdown to the cold condition was started. The emergency plan was initiated at the Unusual Event level. The NRC was notified by use of the emergency notification system (ENS) at 12:55 P.M. The main generator was disconnected from the electrical transmission system (line) at 5:45 P.M. In accordance with procedures, the reactor was manually scrammed at 6:20 P.M. from approximately 15 percent power. RHR system A was placed in service in the shutdown cooling mode at 2:56 A.M. on May 8, 1991. A reactor coolant temperature of less than 212

degrees fahrenheit (cold condition) was achieved at 3:30 A.M. The Unusual Event was formally terminated at 4:00 A.M.

At 9:55 A.M. a test determined that the rate of leakage past the seat of angle globe valve 10MOV-27A was approximately 5,100 gallons per minute (gpm). The RHR loop A continued to be used for shutdown cooling to remove decay heat. A damaged stem nut was found on 10MOV-25B. On May 12th at 1041 the repairs and post-work testing of LPCI inboard injection gate valve 10MOV-25B were completed.

Shutdown cooling was then transferred from the RHR loop A to the RHR loop B at 1410 to permit investigation of the seat leakage in RHR loop A valve 10MOV-27A. Inspection of the internals of angle globe valve 10MOV-27A found fracture of the valve stem and severe damage to the seat, disc, and disc guide ribs. It was necessary to remove the valve from the system to facilitate internal machining and welding repairs.

Cause

Valve 10MOV-25B failed to fully open or close due to the excessive force required to move the valve stem which in turn tripped the motor torque switch. This switch then interrupted the motor power supply in accordance with design. The cause of the excessive torque was excessive friction between the mating acme screw threads of the fixed stem nut and the moving valve stem. Inspection of the internal thread of the stem nut found severe wear and missing, broken, and jammed pieces of the thread. The stem nut is machined from soft (relative to steel) bronze. The valve stem is machined from stainless steel. The moving stem mechanism had been lubricated on a regular basis. The stem nut had not been replaced since manufacture of the valve.

A root cause, investigation of the wear and ultimate failure of the stem nut was performed. The stem nut was cut in half and subjected to metallurgical analysis. The analysis concluded that the stem nut failed due to wear. A conservative estimate of 1,000 open/close cycles was established during the 15 years since installation of the valve. The wear may have been accelerated due to repeated mechanical overloading of the stem nut. The mechanisms which may have contributed to overload include:

1. Operating the valve at excessive differential pressure across the valve during surveillance testing. This would cause overload because the operator torque switch is bypassed in the full closed position and for one third of the operating stroke. The basis for

this conclusion is that the reliability and the calibration of the gauges used to measure the differential pressure are suspect. The gauges were subjected to high vibration and pressure pulsations which damaged the gauges or resulted in the gauges being out of calibration. New calibrated gauges have been installed.

2. Inadequate (infrequent) lubrication and/or contamination of the threads with dirt and debris from nearby modification activities.

3. Pressure locking of the valve due to trapping high pressure water in the valve bonnet and between the seats may also have occurred and could result in overload of the stem nut threads even if the differential pressure across the valve was zero psig. This is discussed in LER-91-014.

The preventive maintenance program was not effective in identifying the degradation of the stem nut. The MOV diagnostic testing system cannot identify stem nut wear on the Size 4 old style operators because of the many mechanical actions occurring in the first few tenth's of a second of operation. Gear backlash, the change of direction in thrust loading, and mechanical clearances make it difficult to assess stem nut wear.

A root cause investigation and determination of the cause of the failure of the valve stem and damage to the disc guide ribs, disc, and seat of the angle globe valve 10MOV-27A was conducted. The investigation determined that the valve stem broke inside the valve due to vibration. The valve guides, seat, and disc were damaged when the valve disc impacted the valve internals.

The metallurgical report concluded the stem failure was caused by fatigue. The fatigue failure was caused by cyclic s
resses resulting
from flow induced forces and vibration. Although the broken ends were damaged from pounding together and interfered with the metallurgical analysis, sufficient evidence remained to indicate the failure mechanism, The failure initiated circumferentially around the stem and propagated radially inward when the material pulled apart near the center causing the small cavity in the lower piece.

This conclusion is supported by the damage to the stem and disc. The damage to the disc occurred at three locations adjacent to the valve guides indicating that most of the damage occurred while the valve stem was intact. The stem has an anti-rotation key which prevents stem and disc rotation. If the stem had failed early on, the conclusion is the

damage would be more general on the outside edge of the disc because it would have been free to rotate in the valve.

The stem failure and the disc damage indicates the stem and disc vibrated with an orbital motion (not rotation). This mode of vibration would cause a bending moment stress to rotate around the stem in the area of the failure with the failure initiating in the area of highest stress. The frequency of the vibration would determine the time to failure.

Several factors which may occur alone or simultaneously and cause natural resonant frequency vibration of the valve stem and disc resulting in cyclic stresses leading to fatigue failure are:

1. Flow forces in the general direction toward the discharge end of the valve.

2. Cavity resonance due to flow of water past the bore in the top of the valve body.

3. Vortex (eddy) shedding off the disc into the water flow path.

A second root cause is the misapplication of this valve in this service. A review of the NSSS description of the RHR/LPCI system indicates that this valve would be used to control flow after a LOCA and LPCI operation and during SDC mode of operation. The architect engineer (AE) for the plant prepared the purchase specification for this valve. Valve Specification APO-13A, Paragraph 5, states responsibility for design by the vendor for the operating conditions

specified. Technical Data Sheet, Page 3, details the operating condition. The only piece of data on the sheet that tells the vendor that the valve will be used to control flow is the terminology "Full Positioning". To meet the design the AE designated the following: 24 second stroke time, 18" globe valve, VAW-90CN, is the AE designation for an angle globe, 326 PSIG delta P and 245 degrees F. With this information the vendor went to his catalog and, by cookbook method, selected Figure #19053WE. In essence, the AE had all but selected this valve type since the AE must have had the catalog in his possession when the purchase spec was written. This valve was not special and is still available in the current catalog. The vendor chief engineer related that they do not manufacturer flow control (throttling) valve. Had the vendor been fully aware of the service condition, they would not have bid the job.

The root cause, was that adequate engineering information did not accompany the specification for the vendor to supply a properly designed valve for the intended service.

Analysis - Reportability

One primary containment isolation valve in each of the redundant RHR/LPCI systems was inoperable. Therefore, both trains of the RHR/LPCI subsystem were inoperable. Technical Specification 3.5.A.6 requires reactor shutdown to the cold condition within 24 hours if both LPCI subsystems are inoperable. Accordingly, this event is reported under the provisions of 10CFR50.73 (a) (i) (A) as a completion of a reactor shutdown required by Technical Specifications.

Analysis - Containment Isolation

Technical Specification Table 3.7-1, "Primary Containment Isolation Valves", lists three valves in each RHR LPCI subsystem to maintain isolation of, the primary ,containment if it is required. Air operated testable check valves (10AOV-68A/B) are inside the primary containment. To reduce maintenance and associated personnel radiation exposure, Technical Specification Amendment 40 in 1978 increased the permitted pneumatic leak rate for these valves to 11 cfm. The valves are tested to this criteria in accordance with Technical Specification Section 4.7.A.d.(1). This leak rate is on the order of 100 times the leak rate permitted for other containment isolation valves of a similar size. To compensate for this increase in the permitted leak rate, an additional valve (10MOV-27A/B) was added to the list of designated primary containment isolation valves. Both (one in each loop) of the air operated testable check valves inside primary containment were operable. Outside the containment two motor operated

valves (10MOV-25A/B and -27A/B) are installed. One of these two valves remained operable in each of the two loops. Therefore, primary containment isolation function was always available and operable.

Analysis - Removal of Residual Heat

The operation of loop B was impaired by the inability to fully open gate valve 10MOV-25B. Subsequent testing did demonstrate that the valve could be fully opened (if required) by momentarily bypassing the torque switch and thermal overload protection. The fully redundant loop A was always available for operation. This was demonstrated by actual use of loop A to remove reactor decay heat over a period of more than four days until

loop B was restored to operation.

Corrective Action

1. The reactor was shutdown to cold condition within 24 hours.

2. The stem nut on isolation gate valve 10MOV-25B was replaced and the valve returned to service within 5 days of discovery of the inoperability.

3. Throttle globe angle valve 10MOV-27A was removed from the system for repair. Upon completion of repairs, the valve was reinstalled in the system.

4. A root cause investigation for both valve failures was completed.

5. The preventive maintenance program will be revised to provide for a stem nut inspection interval for these valves.

6 The system throttling point will be moved to another point in the system provided the NSSS vendor review of the proposed modification shows appropriate Appendix K and system design requirements will be met.

7. The throttle valve vibration frequency spectrum and acceleration is being evaluated. Should acceleration exceed recommended industry levels, appropriate corrective action will be taken.

8. Valves 10MOV-27A/B are being placed in the full open position to reduce vibration during use of the shutdown cooling mode.

9. Other valves which have experienced excessive vibration have been identified. These valves will be opened, and inspected to establish whether any damage has been experienced that requires corrective maintenance.

10. A review of the less sensitive safety-related valves which are used in a throttling service is on-going which determines if a misapplication of service is occurring. (Example: 14MOV-26A core spray test return valve)

11. A review of the current valve purchase specifications has been completed to ensure that the throttling data is provided to vendors in the future.

Additional Information

1. Component Motor Operator
Component Identification: 10MOV-25B
System: RHR/LPCI Loop B
Function: Inboard Injection & Primary
Containment Isolation
IEEE Function Codes: 84
NPRDS Component Code: VALVOP
Manufacturer: Limitorque
NPRDS Vendor Code: L200
Model: SMB-4T
Old Style with Thrust Adaptor
Pre-1967 Design No Longer Manufactured
Size: 4
Power Ratio: 32.8 HP
Design Current: 35.8 Amps
Voltage: 575 Volts
Closing Time: 24 Seconds

2. Component: Globe Angle Valve, Motor Operated
Component Identification: 10MOV-27A
System: RHR/LPCI Loop A
Function: Outboard Injection Throttle & Primary
Containment Isolation
IEEE Function: INV & ISV
NPRDS Component Code: VALVE
Manufacturer: Powell
NPRDS Vendor Code: P305
Model: 19053
Type: Globe Angle
Size: 18 Inch
Pressure: 900 Psig
Motor Operator Type: Limitorque SMB-4T
Old Style with Thrust Adaptor
Pre-1967 Design No Longer Manufactured

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New York Power Radford J. Converse
Authority Resident Manager

October 4, 1991
JAFP-91-0638

United States Nuclear Regulatory Commission
Document Control Desk Mail Station P1-137
Washington, D.C. 20555

SUBJECT: DOCKET NO. 50-333
LICENSEE EVENT REPORT: 91-006-01
Manual Reactor Shutdown-Both
RHR/LPCI Loops Inoperable

Dear Sir:

This report was submitted in accordance with 10CFR50.73 (a) (2) (i) (A), completion of a shutdown required by Technical Specifications on June 6, 1991.

This supplement provides the results of the root cause analysis of the failure mechanisms for the two RHR/LPCI valves which were inoperable and caused the event. Additional corrective actions have been listed to address the root causes identified in the analysis.

Questions concerning this report may be addressed to Mr. Hamilton Fish at (315) 349-6013.

Very truly yours,

RADFORD J. CONVERSE

RJC:HCF:lar

Enclosure

cc: USNRC, Region I
USNRC Resident Inspector
INPO Records Center

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